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QOS PARAMETERS FOR REAL-TIME TRAFFIC IN VEHICULAR COMMUNICATION

Abubakar Aminu Mu'azu
Department of Mathematics & Computer Science,
Umaru Musa Yar'adua University
Katsina, Nigeria

Ibrahim A. Lawal
Department of Computer Science,
Federal College of Education Kano,
Nigeria

Abstract

Quality of Service (QoS) provision for vehicular ad-hoc networks (VANET) is an important issue to consider for packet transmission. The need for an efficient and reliable communication place high displacement of vehicles interesting and making QoS provisioning a challenging issue.Its focus is to check which of the approaches to QoS is theoretically optimal or suboptimal but stable in path computation and to analyze problems that occur when QoS is employed in a VANET environment. As such, the paper contributes to the field by highlighting the state of the art in finding and providing guaranteed QoS parameters for real-time applications. This may aid in avoiding loss of safety information in critical situation. The emerging IEEE 802.11p standard adopts the enhanced distributed channel access (EDCA) mechanism as its Media Access Control (MAC) scheme to support QoS in the rapidly changing vehicular environment. Based on the model, we analyse the throughput and broken link performance of differentiated service traffic, and seek solutions to optimally adjust the parameters of EDCA towards the controllable QoS provision to vehicles. This help to minimize the number of retransmission issues and achieved better delivery ratio and provide ~~is~~a more stable routes as it significantly shows a fewer broken links.

Keywords: Quality of Service (QoS) Parameter, routing, vehicular communication

INTRODUCTION

Vehicular Ad Hoc Networks (VANETs) are part of the Intelligent Transportation System (ITS), which aims to provide safety-critical and commercial services on the road. ITS in general are advanced applications aimed to increase traffic safety on the road (Balasubramanian *et al.*, 2008). Basically all traffic safety applications are critical and require that a message reaches its intended recipient before a particular time instant (e.g., a crash as in event-driven hazard warning systems). Different applications have different Quality-of-Service (QoS) requirements. The traffic of safety applications has stringent requirements on highly reliable and real-time transmissions, while the non-safety applications require efficient and high throughput.

VANETs is a technology that uses moving vehicles as nodes in a network to create a mobile network. They are subgroup of mobile ad-hoc network (MANET) that does not rely on any fixed network infrastructure. It therefore turns every participating vehicle into a wireless router(Balasubramanian *et al.*, 2008) or node, allowing vehicles to communicate with each other via wireless channel, approximately 100 to 300 meters of each other to connect and, in turn, create a network covering a wide range. The communications between nodes are direct links that also facilitate the vehicular networks for serving geographical data or a gateway to internet etc (Balasubramanian *et al.*, 2008)These nodes may have access to a more complete view of the network topology and to additional information that may also improve not only routing but also providing QoS guarantee in a dynamic environment. Due to this nature of Vehicle to Vehicle (V2V) communication, the transmission of real-time messages in VANET is time sensitive. The real-time messages from source to destination need to be transmitted within due time and with little delay bound.

By enabling vehicles to communicate with each other, VANETs employs three (3) kinds of communication types. These include Vehicle to Vehicle (V2V-centred), Vehicle to Infrastructure (V2I-centred) and Vehicle to Roadside (V2R-centred)(Cunha *et al.*, 2016). Therefore vehicular networks could contribute to safer and more efficient roads. Communications between vehicles and within the same vehicle (V2V) is becoming a promising field of research and we are moving closer to the vision of ITS, which can enable a wide range of applications, such as collision avoidance, emergency message dissemination, dynamic route scheduling, real-time traffic condition monitoring and any kind of "infotainment" information spreading (i.e. movies, gaming and advertisement).

Vehicles dynamically change their position and exchange data between each other through wireless links in vehicular networks. These networks cover many applications such as safety on the road, warning drivers about accidents, congestion ahead on the road or sending information to allow a server to centralize information from all vehicles about such matters as mechanical state, position, street status and emergency situations. The infrastructure-less of VANET makes routing of data packet an interesting issue(Korichi, Lakas and El Amine Fekair, 2016)(Zheng *et al.*, 2014). Routing process in a network context is completed by the implementation of some certain routing algorithms. The route discovery process for transmission of message is illustrated in the Figure 1.

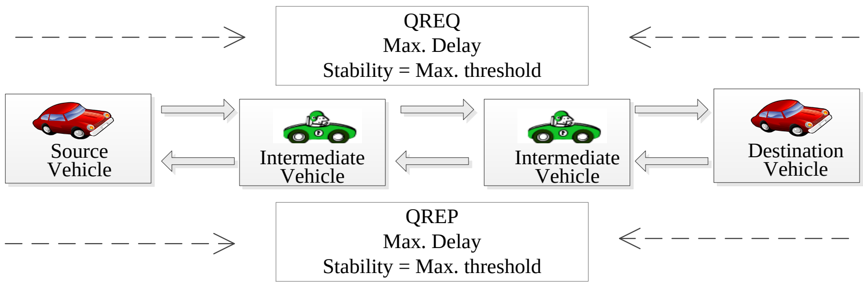

Figure 1: Route Discovery Process

A vehicle which receives a route request (RREQ) with a QoS extension must agree to meet that service requirement (delay bound) in order to rebroadcast the RREQ in addition to route stability. This paper aims at highlighting the state of the art in finding and providing guaranteed QoS parameters for real-time applications. This may aid in avoiding loss of safety information in critical situation.

STATE OF THE ART

It is obvious and important to make the real-time safety traffic applications effective with timely delivery and less delay especially for vehicular network. Despite the high speed of the mobile nodesin VANETs and frequent topology changes, it is important to explore ways to enhance and make efficient,the network technology. Data traffic with a wide emergency application requirements in VANET tend to demand for new and proper control and management mechanisms for of communication networks(Lee *et al*., 2014).

The term QoS, just as its name implies, describes the measure of service used to express the level of performance provided to users. Another definition from(Veres *et al*., 2001)is offering resources to high-priority service classes at the expense of lower-priority classes. The main aim of QoS provisioning is to achieve a more deterministic network behavior, by doing so the information carried by the network can be better delivered and network resources can be better utilized.

Several research works dealing with the design of VANETs routing protocols have been studied (Hung, Wang and He, 2016) and (Cunha *et al*., 2016), deals with issues on how to increase the packet delivery ratio, reduce the possibility of packet loss rate and how to minimize the end-to-end delay. The issue is to build a realistic simulation environment, but with optimum conditions regarding the unspecified VANETs parameters. The work of (Hung, Wang and He, 2016) proposes a flexible and cost effective approach for real-time multimedia application in a network to evaluate and manage QoS parameter. The approach uses packet delay, jitter, packet sequence number and packet loss as QoS constraints of real-time application with no any packet processing delay between two points. Some certain principles to provide guarantees in a network for real-time applications are discussed in

(Forouzan and Mosharraf, 2016) which include the classification of packets, differentiation of traffic flows, call admission and use of resources.
An increasingly important application of real-time traffic requires a stringent QoS guarantees because there are some essential differences between the non-real-time data and real-time traffic data(Hung, Wang and He, 2016). For the transmission of non-real-time data, timing is not a critical issue, the data is elastic. But it always has high requirement for packet loss (retransmissions are used if there are some lost packets). Table 1 illustrates the concern with regards to the timeliness of message delivery along with chances of data packets loss for real-time/non real-time application in VANET environments.

Table 1: Real-Time and Non-Real-Time Applications

Real-Time Application	**Non- Real-Time Application**
Timely transmission of packets is concern as to destination in due time	In non-real-time data time is not the concern because data is elastic.
Critical safety messages have tolerance level almost zeros	Non-real-time network could perform better but cannot assure timely delivery of data on time.
QoS mechanisms are required to ensure high stable connection.	It always has high chances for packet loss.
For example like video streaming	Retransmissions are used if there are some lost packets. Such as FTP, E-mail and web browsing

The work of(Boniface et al., 2010)proposes a flexible and cost effective approach for real-time multimedia application in a network to evaluate and manage QoS parameter. The approach uses packet delay, jitter, packet sequence number and packet loss as QoS constraints of real-time application with no any packet processing delay between two points. Some certain principles to provide guarantees in a network for real-time applications are discussed in(Forouzan and Mosharraf, 2016)which include the classification of packets, differentiation of traffic flows, call admission and use of resources.

Usually, when packets of the different traffic class are place in the same queue, the incoming packets could otherwise be treated differently, hence high occurrence of packet loss and packet delay is inevitable. The tradeoff between timeliness and reliability in wireless network requires the appropriate consideration for the right transport protocol. As such, UDP is used as the transport protocol to transmit real-time application to satisfy the timeliness delivery of packet to the user. Packet loss tends to occur randomly between two nodes during transmission in the real-time application environment. The QoS parameters are discussed in the following.

a) Latency means time duration between issuing a message from sender until it is received by destination vehicles(Hung, Wang and He, 2016). It is an important parameter for multimedia application that requires certain consideration to optimize the end-to-end delay. The real-time application between two RTP packets are sensitive to delay constraint and can be expressed as :

$$D_{(i,j)} = (Rt_j - Rt_i) - (St_j - St_i)$$
$$= (Rt_j - St_j) - (Rt_i - St_i)$$

$Rt_i \& Rt_j$are the arriving time in RTP timestamp for $i \,\&\, j$ whereas $St_i \& St_i$ represent the packets i and j timestamp in RTP respectively.

b) Packet Loss Rate (PLR): Certain level of packet loss is tolerable in real-time application transmission but requires a timely delivery.Timely delivery of real-time applications in VANET is a crucial issue as the packet arrives late will cause it to be dropped or loss at the receiving vehicle (regarded as dropped packet loss). The high mobility of vehicles as well as complex radio environment in VANET makes the packet loss rate especially for real-time packet an important issue. PLR however provides the estimation of loss packet and impacts the transmission control of any routing algorithm by evaluating of the link quality. The packet loss rate is based on the statistical principals of packet loss rate given in (Rawat *et al.*, 2014) and probability density of different distances from GMM (Gaussian Mixture Model.

Different distances obtained from GMM of the probability distribution function (PDF) of the packet loss can be written as

$$G_{Vd}(x) = \sum_i^y \varpi_i Tx(x|\eta_i, \beta_i),$$

V_d represents the distance between two vehicles, y represents the number of single Gaussian, ϖ_i represents the weight of the i - th Guassian, (all are positive and the sum is 1)

η_i is the mean of each parameter, β is the covariance matrix.

The values of these parameters are calculated and determined in (Rawat *et al.*, 2014) using the statistical probability of x in k-Gaussian.Therefore, to estimate the real-time packet loss rates in VANET, vehicle current distance as well as the packet rate at that distance is needed (to be obtained) by sending probe message and based on the GMM of that distance. The overall procedure for the real-time estimation is defined as follows;

Let two vehicles X and Y both travelling in direction$Z$, vehicle X transmitted packets Tx at time t sec, such that $t < 1sec$, vehicle Z receives Rx broadcasting packets.

Let Tx be the transmitted packets

$\lambda(t)$ be the measured packet loss rate value at time $t(t < 1s)$

P_{lk} be the packets loss rate of the link

For every sending packet from vehicle X to vehicle Y, the packet loss rate of the link is expressed as:

$$X \rightarrow Y = \lambda(t),$$

$$\lambda_i(t) = \frac{Rx}{Tx} \times 100\%$$

$\lambda(t)$ parameter is the measurement value of the packet loss rate during time t and $(t < 1s)$.

Then, for the second current packet loss rate $\lambda_j(t)$, the distribution $N_{MAP}(x_i|\eta_i, \beta_i)$ that the $\lambda_j(t)$ follows should be determined and MAP is used to achieve this which is given by: . (MAP estimate the posterior distribution mode which is used to estimate the unobserved quantity based on empirical data (Gauvain and Chin-Hui Lee, 1994).

$$N_{MAP}(x_t|\eta_i, \beta_i) = \arg\max_N \frac{f(x_t|N)\, g\,(\mathrm{N})}{\int(\mathrm{x_t}|N)\,\mathrm{g}\,(\mathrm{tx})dN},$$

Gausian distribution function is represented by N

$$\Rightarrow \quad \eta_{MAP} = \arg\max_\eta \frac{f(x_t|\eta_j)\, g\,(\eta_\mathrm{j})}{\sum_{i=1}^{k} f(\mathrm{x_t}|\eta_i)\,\mathrm{g}\,(\eta_\mathrm{i})dN},$$

Where $g\,(\eta_\mathrm{i})$ is the i-th GMM wieght ϖ_i and $f(x_i|\eta_i, \beta_i)$ is the probability that $x(t)$ is subset of $N_{MAP}(x_t|\eta_i, \beta_i)$ which is the environmental distribution factor that mostly affects the link quality. And also having the highest likelihood of packet loss rate $x_{\max}(t)$ expressed as:

$$x_{\max}(t) = \eta_{MAP}, (\mathrm{x_t} \subseteq [0 \to \infty])$$

With regards to the QoS metrics for real-time applications in VANET, Wang in(Baugher et al., 2004) discussed the connection duration, route lifetime, and route repair frequency in VANET.

The simulations were conducted on a closed rectangular highway with an unrealistically small transmission range (from 100 to 150m) for highway environment. Therefore, results for QoS routing in VANET are relatively scare due to the aforementioned difficulties..

EDCA Strategy of IEEE 802.11P to Improve Vehicle Safety Communication

In this section, we present an overview of IEEE 802.11p MAC protocol and its EDCA mechanism to reduce frame collisions for a channel dominated by periodic safety messages.

The effectiveness of DSRC for collision avoidance depends on the communication performance of safety messages. EDCA, the standard IEEE 802.11 QoS capability, was designed for networks with a mix of voice, video and best effort traffic. The EDCA mechanism defined in IEEE 802.11e has been well studied both theoretically and experimentally for the WLAN. In the context of vehicular networks, EDCA has been studied in (Boniface *et al.*, 2010). The author in(Boniface *et al.*, 2010) and (Rawat *et al.*, 2014) have done a simulation study on the effect of IEEE 802.11e EDCA parameters on the performance of safety message transmission. The study was conducted for a scenario with only one high priority node.

METHODOLOGY

SIMULATIVE PERFORMANCE EVALUATION

Simulations are carried out with the Wireless Access Radio Protocol II (WARP2) NCTUns Network simulation environment. The WAVE MAC and PHY protocols have been implemented in WARP2. All simulations are performed with the WAVE CCH/SCH multi-channel architecture as (Lee *et al.*, 2014). The simulation parameters considered for the experiment are listed in Table 2. Adhere to the DSRC's seven-channel bandplan, the Ch178 was used as the Inter-Cluster Data (ICD) channel.

Many different nodes in ad hoc network can establish a communication among themselves in a real environment. As number of sources increase due to the nature of radio communications, the performance of communication reduces especially for high sensing ranges.

Table2: Simulation Parameters

Parameter	**Value**
Number of vehicles	10-100
Scenario Area	1000 m x 1000 m
Simulation Time	400 seconds
Vehicle's Speed	40 to 120 km/h
MAC Specification	IEEE 802.11b/ IEEE 802.11p
Channel Bandwidth	2 Mbps
Traffic Type	CBR/UDP
Packet size	1000 bytes
No. Transmissions	3
Data Transmission Range (DTR)	100, 150, 200, 250 and 300 meters
Pause Time	0, 50, 100, 150, 200, 250, 300, 350, 400
Propagation Model	Two Ray Ground Model
Priority Queue size	Set to 50 packets.
Examined routing protocol	AODV/DSR
Route Request Retransmit Interval	500m

It is more apparent for the scenario of the same node density, that the channel access might be busy due to other transmissions as shown in Figure 3

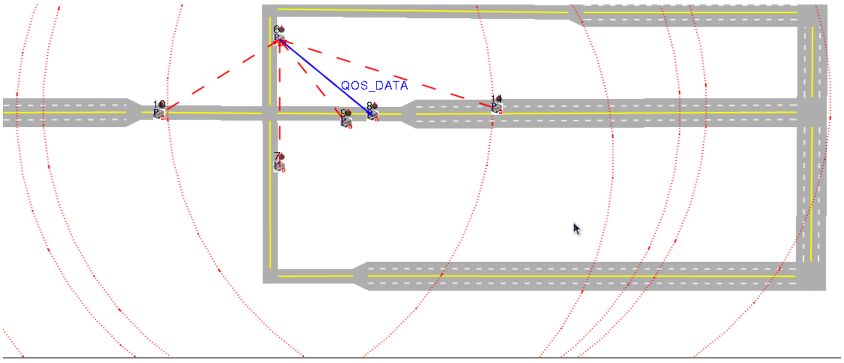

Figure 3: QoS Real-Time Data Transmission Scenario in VANET

RESULTS AND DISCUSSION

Performance Metrics

A. <u>Network Throughput</u> is considered one of the most favorite metrics to evaluate the system performance of any routing protocol. It is considered as the average data rate transfer that gives the total number of received packets at the destination out of total transmitted packets. Uncertainty in topology changes and unreliability in wireless channels access affect throughput in VANETs. The Constant Bit Rate (CBR) connection pattern is also used in the proposed simulation. Constant bit rate means consistent bits rate in traffic are supplied to the network. Pair t-test analysis was performed for the average throughput values in the proposed algorithm, AODV and DSR as shown in Table 3.

Table 3: Average Network Throughput with Respect to Node Mobility

		Paired Differences					
					95% Confidence Interval of the Difference		
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	Sig. (2-tailed)
Pair 1	Algorithm - Throughput1	-3.427333E1	15.270085	3.116993	-40.721325	-27.825342	.000

The significant level obtained in Table 3shows that the throughput means of the proposed algorithm, AODV and DSR are statistically different and are not likely due to chance. Therefore we can conclude that the proposed scheme significantly achieved greater throughput. Figure 3shows the graph for the same results from the series of experiments.

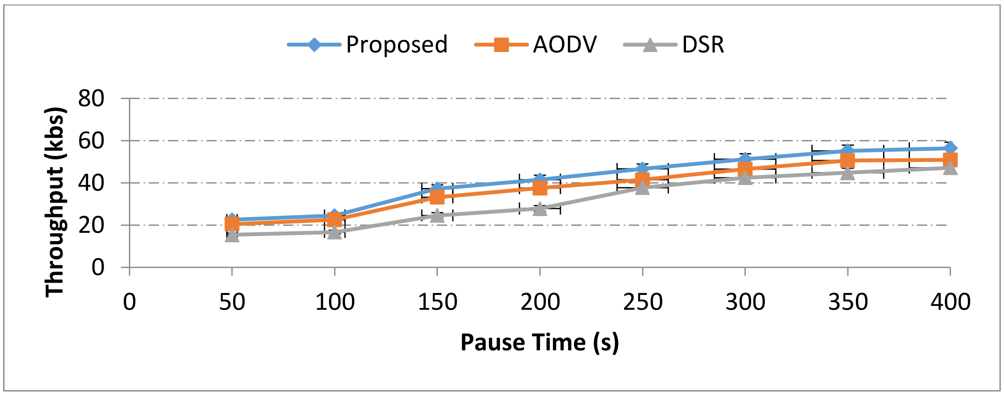

Figure 3: Average Network Through with varying the speed of Vehicles

As seen in Figure 3, the proposed scheme throughput starts by experiencing a slightly improvement of 9.8% over AODV protocol and 30.8% than DSR on highway scenario where the traffic generation is comparatively low. With varying pause time for number of CBR connections, the proposed scheme outperformed the two protocols with having approximately same values of throughput with AODV. This is because it considers the interferences level for transmission of high priority safety messages by switching to other channel with less interferences.

B. <u>Broken Links</u>

Absence of a vehicle between the source and destination vehicles usually leads to a link breakage. Broken links in VANET occur during data transmission as a result of high mobility of the vehicles and rapid topology changes which lead to the transmission of more control packet for route repair. Link failure is an important parameter for real-time communication and is very difficult to maintain undistracted transmission of data with increase in mobility and traffic. The stability evaluation characterized by number of broken links. Table 4 gives the results obtained from pair t-test analysis.

Table 4: Average Broken links with Respect to Node Mobility

	Paired Differences					Sig. (2-tailed)
				95% Confidence Interval of the Difference		
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	
Pair 1 Algorithm - Broken_Lks1	-1.828000E2	47.126274	12.167952	-208.897661	-156.702339	.000

From the Table 4 it can be concluded that the means of the proposed algorithm with the relaxation in the level of significance (α), significantly differ from the means of AODV and DSR.

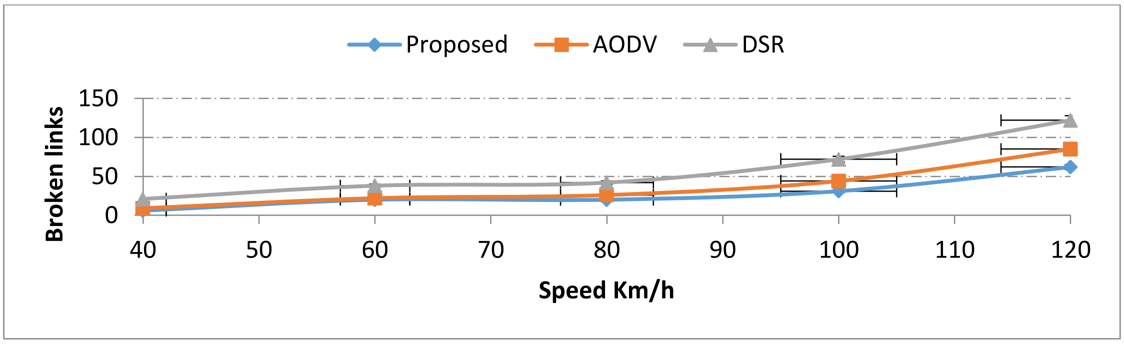

Figure 4: Number of Broken links with varying the speed of Vehicles

In the simulation, vehicles are grouped according to sending node perspective with their velocity vector. Figure 4 shows the broken links (that indicate stability) of proposed scheme, AODV and DSR with respect to varying speed of the vehicles. At the beginning, both the proposed scheme and AODV protocol experience similar trends for broken links. It can be seen that increase in speed, the occurrence of broken link is higher, so the stability of the link deteriorates.

CONCLUSION

In this paper, we studied the parameters used for real time communication in vehicular network. It shows that the effectiveness of DSRC for collision avoidance depends on the communication performance of safety messages. EDCA, the standard IEEE 802.11 QoS capability, was designed for networks with a mix of voice, video and best effort traffic. An increasingly important application of real-time traffic requires a stringent QoS guarantees because there are some essential differences between the non-real-time data and real-time traffic data. Particularly, the QoS parameter analysis for some parameters presented in our paper has been proved to be an efficient real-time communication for the safety application. As the next step of this work, we would proposes a new algorithm for multi-constrained QoS routing in vehicular network by adopting TDMA clustering approach. In this algorithm design, some QoS parameters will be used in addition to the stability metric for finding and establishing an efficient and reliable route to destination.

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